

New Muricidae (Mollusca: Neogastropoda) from the Lower Miocene Cantaure Formation of Venezuela

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ABSTRACT. Seven new muricine records are added to that for the Lower Miocene Cantaure Formation of Venezuela, four of which are new: *Siratus harzhauseri* nov. sp. *Ocenebra etteri* nov. sp., *Typhina canaliculata* nov. sp. and *Laevityphis jungi* nov. sp., and three are identified to genus level *Phyllonotus* sp. cf. *P. infrequens* (Vokes, 1963), *Purpurellus* sp. cf. *P. repetiti* (Vokes, 1970) and *Vitularia* sp. cf. *V. salebrosa* (King & Broderip, 1832). The genus *Ocenebra* is recorded in the western Atlantic for the first time.

KEYWORDS. Muricidae, Mollusca, Miocene, Cantaure Formation, Venezuela, new records, new taxa.

INTRODUCTION

In his landmark monograph on the molluscan assemblage of the Cantaure Formation, Jung (1965) recorded and described ten muricine species from the deposits. Further new species were added in the 1990's by Vokes (1992, 1994, 1995), Vermeij & Vokes (1997), and later by Vermeij (2001) and Landau & Vermeij (2010). A full list of all species described or recorded from the Cantaure Formation subsequent to Jung's (1965) monograph were listed by Landau & Vermeij (2010, p. 105, appendix 1). A short account of the geographical and stratigraphical range was given by Landau & Vermeij (2010, p. 99). This will not be repeated here, except to say that the assemblage is now considered to be late early Miocene in age (Landau *et al.*, 2012, p. 258, chart 18). In this contribution to the knowledge of the gastropod assemblage found in the late early Cantaure Formation

of Venezuela, we focus on new species, or taxa not previously recorded from the assemblage. This increases the number of muricine species known from the formation to 29.

Material and methods

The material described here is from the Gibson-Smith collection housed in the Naturhistorisches Museum Basel (NHMB coll.), Switzerland and the Bernard Landau collection (BL coll.), now deposited in the Naturhistorisches Museum Wien (NHMW coll.), Vienna.

The classification adopted here is according to WoRMS (<http://www.marinespecies.org/index.php>). The descriptions adopt the terminology suggested by Merle (1999, 2001) (Figs 1, 8), see next page:

P	Primary cord
s	secondary cord
t	tertiary cord
Ad	adapical (or adapertural)
Ab	abapical (or abapertural)
SP	Subsutural cord
IP	Infrasutural primary cord (primary cord on shoulder)
adis	adapical infrasutural secondary cord (shoulder)
abis	abapical infrasutural secondary cord (shoulder)
P1	Shoulder cord
P2-P6	Primary cords of the convex part of the teleoconch whorl
s1-s6	secondary cords of the convex part of the teleoconch whorl
example: s1 = secondary cord between P1 and P2; s2 = secondary cord between P2 and P3, etc.	
ADP	adapertural primary cord on the siphonal canal
MP	median primary cord on the siphonal canal
ABP	abapertural primary cord on the siphonal canal
ads :	adapertural secondary cord on the siphonal canal
ms :	median secondary cord on the siphonal canal
abs :	abapertural secondary cord on the siphonal canal

SYSTEMATIC PALAEONTOLOGY

Superfamily **MURICOIDEA** Rafinesque, 1815
Family **MURICIDAE** Rafinesque, 1815
Subfamily **MURICINAE** Rafinesque, 1815
Genus *Siratus* Jousseauime, 1880

Type species. – *Murex senegalensis* Gmelin, 1791, by original designation. Recent, Brazil.

Discussion. As discussed by Barco *et al.* (2010), *Siratus* Jousseauime, 1880 is closer to *Vokesimurex* Petuch, 1994 than it is to *Chicoreus* de Montfort, 1810, and all three should be used at full generic rank. Merle *et al.* (2011, p. 72) discussed the difficulty in separating some species of *Siratus* from *Vokesimurex*. They suggested that well-developed secondary internal denticles and numerous columellar denticles distinguished many *Siratus* from *Vokesimurex*, but that these characters are variable. A more reliable character is the shape of the siphonal canal, which is bent in *Siratus* and straight in *Vokesimurex*. The new species from Cantaure has weak apertural dentition on both lips, which can be present in either genus, but the siphonal canal, although incomplete, is clearly bent, placing it in the genus *Siratus*.

Siratus harzhauseri nov. sp.
Figures 1, 9-11

Dimensions and type material. Holotype; NHMW 2013/0476/0010 (ex BL coll.) (Figs 1, 9-11), height 48.6 mm.

Etymology. Named for Mathias Harzhauser of the Naturhistorisches Museum Wien, friend of the senior author, in recognition of his contributions to palacomalacology.

Type locality. 1 km southwest of Casa Cantaure, about 10 km west of Pueblo Nuevo, Falcón, Venezuela (= locality GS1PGNA of Gibson-Smith & Gibson-Smith, 1979).

Type stratum. Cantaure Formation (late early Miocene: Burdigalian).

Diagnosis. A medium sized *Siratus* species, with a relatively elongated shell, a narrowly canaliculated suture, three varices per whorl bearing short, stout spines placed mid-whorl, with three intervarical axial ridges on early whorls, four with prominent tubercles mid-whorl on last 1½ whorls.

Description. Shell medium-sized, fusiform, spire tall. Protoconch not preserved. Teleoconch of six high, weakly-shouldered whorls, with a narrow, concave, sub-horizontal subsutural area; whorls convex below. Suture impressed, shallowly canaliculated. Three elevated varices per whorl, placed at 120°, aligned almost vertically, bearing a short, stout spine placed just above mid-whorl corresponding to P1, giving whorls a somewhat angular appearance. Intervarical axial sculpture consisting of three nodulose ridges on early whorls, increasing to four on abapical half of penultimate whorl, where the nodules mid-whorl become more prominent. Last whorl fusoid; subsutural area with IP, adis and abis of almost equal strength. Below shoulder P2-P6 narrow, s2-s6 developed in the interspaces between the primary cords. ADP and MP developed on base, ads and ms weaker. Tertiary cords developed throughout between primary and secondary elements. Siphonal canal below ms missing. Aperture of moderate size, ovate. Outer lip convex, margin erect bearing 16 denticles at the inner edge. Labral varix moderately expanded, rounded, bearing straight spine at shoulder. Anal sinus broad, shallow; siphonal canal incomplete, but long,

narrow, open, pointing slightly to left. Columellar lip well delimited, narrowly expanded, adherent

adapically, erect abapically, bearing elongated denticles along its entire length.

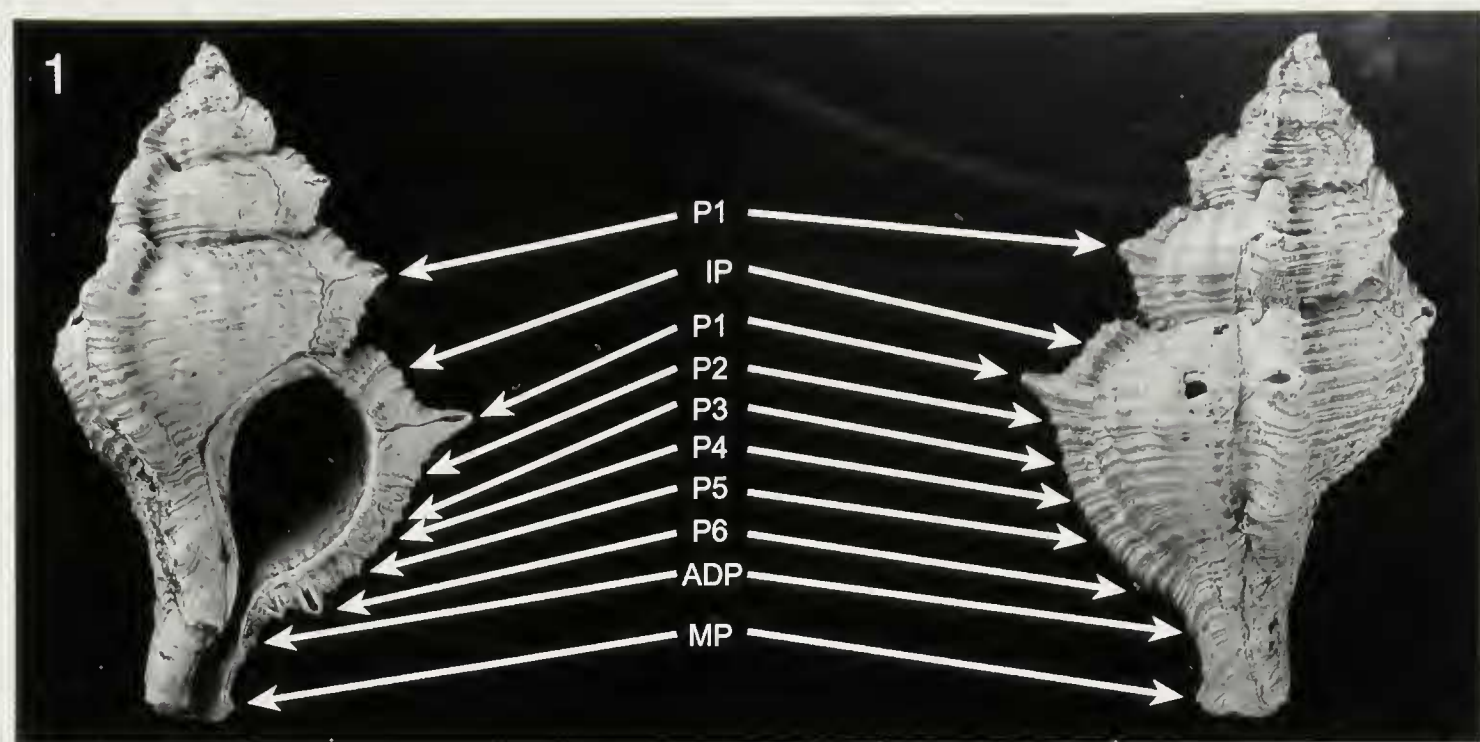


Figure 1. *Siratus harzhauseri* nov. sp., holotype NHMW 2013/0476/0010 (ex BL coll.), height 48.6 mm, 1 km southwest of Casa Cantaure, about 10 km west of Pueblo Nuevo, Falcón, Venezuela, Cantaure Formation, Burdigalian, late early Miocene.

Discussion. *Siratus harzhauseri* nov. sp. is most similar to the Caribbean Pliocene-Recent *S. formosus* (Sowerby, 1841), but differs in having a more elongated fusiform shell shape, in having a shallowly canaliculated suture, in having P1 and hence the shoulder spine placed lower, closer to mid-whorl and shorter, and in having the intervarical axial ridges more strongly nodulose mid-whorl on the last 1½ whorls. *Siratus domingensis* (Sowerby, G. B. I, 1850) from the early Pliocene Gurabo Formation of the Dominican Republic is similar to *S. formosus* and was considered to be ancestral to it by Vokes (1989). Apart for a few exceptionally large specimens, *S. domingensis* is smaller than either *S. formosus* or *S. harzhauseri*, it has smaller spines and a more recurved siphonal canal. *Siratus domingensis* has three-five intervarical axial ridges, which are narrower and the suture is not canaliculated. *Siratus articulatus* (Reeve, 1845) from the Pliocene-Recent Caribbean can easily be separated as P1, P3, P5 and P6 form more or less long spines at the apertural varix and the suture is not canaliculated. Another closely similar species is the early Pleistocene to Recent Caribbean *Siratus springeri* (Bullis, 1964), but this species differs from *S. harzhauseri* in having convex rather than angular whorl profile, in having only two or three axial intervarical ridges, in having the labral varix deeply excavated on the abapertural side, and in most specimens P1, P5, P6 are strongly developed.

Two further *Siratus* species occur in the Cantaure assemblage: *S. quirosensis* (F. Hodson, 1931), which is much smaller than *S. harzhauseri*, with only two axial intervarical ridges that are more prominent than

in *S. harzhauseri*, and P1, P3 and P5 are strongly developed. The second, *Siratus denegatus* (Jung, 1966), is quite different from all its congeners in having a rather triangular shell, a sharply carinate last whorl, only one axial intervarical ridge, very fine spiral sculpture, and P1 developed into a short, sharp spine at the shoulder.

Genus *Phyllonotus* Swainson, 1833

Type species. – *Murex imperialis* (var. a) Swainson, 1833, by subsequent designation, Swainson, 1833, pl. 109 (= *Murex imperialis* Swainson, 1831) (not Fischer de Waldheim, 1807) (= *Murex margaritensis* Abbott, 1958). Recent, West Atlantic.

Phyllonotus sp. cf. *P. infrequens* (Vokes, 1963) Figures 12-13

cf. 1963. *Murex* (*Phyllonotus*) *infrequens* Vokes, p. 156, pl. 1, fig. 4.

Material. 1 specimen NHMW 2013/0476/0011 (ex BL coll.), height 35.3 mm (Figs 12-13).

Locality. 1 km southwest of Casa Cantaure, about 10 km west of Pueblo Nuevo, Falcón, Venezuela, Cantaure Formation, Burdigalian, late early Miocene.

Discussion. This specimen resembles the species illustrated by Vokes (1989, 1990) as *Phyllonotus infrequens* from the Early Miocene Baitoa Formation of the Dominican Republic. However *Phyllonotus*

infrequens from the Early Miocene Chipola Formation of Florida has a more globose shell with a less impressed suture, a more rounded aperture and less conspicuous secondary and tertiary spiral cords. The specimen from the Baitoa Formation and our specimen from the Cantaure Formation are somewhat related, although the Cantaure one is more globose, has a more impressed suture and a narrower siphonal canal.

Genus *Purpurellus* Jousseume, 1880

Type species. – *Murex gambiensis* Reeve, 1845, by original designation. Recent, West Africa.

Emerson & D'Attilio (1969) demonstrated that, on the basis of radular morphology, *Purpurellus* Jousseume, 1880 was closely related to *Pterynotus*. *Purpurellus* differs from *Pterynotus* in having a sealed siphonal canal and an operculum with a central nucleus, instead of apical in *Pterynotus* s.s. The use of the taxon at full generic rank is now generally accepted (Landau *et al.*, 2007, Merle *et al.*, 2011, Bouchet & Houart, 2013).

Purpurellus sp. cf. *P. repetiti* (Vokes, 1970)
Figures 14-17

cf. 1970 *Pterynotus* (*Purpurellus*) *repetiti* Vokes, p. 16, pl. 3, fig. 4.

Material. 1 incomplete specimen, NHMW 2013/0476/0008 (ex BL coll.), height 27.2 mm (Figs 14-15); 1 incomplete specimen, NHMW 2013/0476/0009 (ex BL coll.), height 32.4 mm (Figs 16-17).

Locality. 1 km southwest of Casa Cantaure, about 10 km west of Pueblo Nuevo, Falcón, Venezuela (=locality GS1PGNA of Gibson-Smith & Gibson-Smith, 1979), Cantaure Formation (early Miocene: Burdigalian).

Discussion. Vokes (1989, p. 55) commented that *Purpurellus* species could be difficult to separate. The two incomplete specimens illustrated here resemble the specimen described as *Purpurellus repetiti* (Vokes, 1970) from the “Silverdale Beds” of North Carolina, originally considered Early Miocene, but placed in the Late Oligocene Chiekasawayan Stage by Gibson (1977, p. 202; 1983, p. 38). This species is characterised by its relatively tall spire, moderately expanded varices, with short straight spines at the shoulder, single sharp intervarical node, and very weak spiral sculpture. It is most like the European Miocene-Pliocene *Purpurellus veranyi* (Paulucci, 1866) (see Landau *et al.*, 2007; Merle *et al.*, 2011), but this species has broader intervarical nodes and a relatively smaller, more circular aperture. Apart from these constant differences, most specimens of *P. veranyi* are broader, have stronger, recurved spines at the shoulder, slightly more prominent spiral sculpture,

and more expanded labral varix. However, given the badly preserved material from the Cantaure Formation and the few specimens involved, the identification remains doubtful.

The only other western Atlantic congener is *Purpurellus mirificus* Vokes, 1989 from the early Pliocene Gurabo Formation of the Dominican Republic, which is quite different from *P. repetiti* and *P. veranyi* in having greatly expanded wing-like varices, similar to the Recent West African *P. gambiensis* (Reeve, 1845).

In Europe the fossil record also starts in the Late Oligocene with an undescribed species listed by Lozouet (1986, p. 377) from the Atlantic Late Oligocene of France. Today *Purpurellus* has a disjunct distribution, *P. gambiensis* (Reeve, 1845) from West Africa and two species, *P. pinniger* (Broderip, 1833) and *P. macleani* (Emerson & D'Attilio, 1969) from the Pacific coast of Tropical America. In the fossil record, specimens of *Purpurellus* are always rare, and although the first record is Late Oligocene in both the eastern and western Atlantic, it is likely that the genus is a Palaeogene offshoot of *Pterynotus*, which originated in the Tethys, immigrated to the western Atlantic and colonised the Tropical American Pacific before the closure of the central American Seaway, subsequently dying out in the western Atlantic.

Subfamily **OCENEBRINAE** Cossmann, 1903
Genus *Ocenebra* Gray, 1847

Type species. – *Murex erinaceus* Linnaeus, 1758, by monotypy. Recent, northeastern Atlantic, Mediterranean.

Ocenebra etteri nov. sp.
Figures 18-23

Dimensions and type material. Holotype, NHMW 2013/0476/0018 (Figs 20-21), height 22.3 mm; paratype 1, NHMW 2013/0476/0017 (Figs 18-19), height 17.5 mm; paratype 2, 2013/0476/0019, height 22.4 mm; paratype 3, NHMW 2013/0476/0021, height 12.1 mm.

Other material. NHMW 2013/0476/0020 (1), height 14.0 mm, juvenile (Figs 22-23).

Etymology. Named after Dr. Walter Etter of the Naturhistorisches Museum Basel, Switzerland, in recognition of his help and support.

Type locality. 1 km southwest of Casa Cantaure, about 10 km west of Pueblo Nuevo, Falcón, Venezuela (= locality GS1PGNA of Gibson-Smith & Gibson-Smith, 1979).

Type stratum. Cantaure Formation (late early Miocene: Burdigalian).

Diagnosis. A medium sized *Ocenebra* species with a strongly nodulose shoulder, three varices per whorl on the last three whorls, with one intervarical node, spiral cords P1-P5 equal in strength, P6 slightly narrower, with a single intercalated secondary cord, aperture small with very shallow ID and strong D1-D5 within and a short, sealed siphonal canal.

Description. Shell medium sized, heavy, nodose. Subsutural ramp broad, weakly sloping, slightly concave. Spire high with teleoconch up to five or six strongly shouldered, nodose whorls. Suture adpressed. Protoconch unknown. Axial sculpture of teleoconch whorls consisting of high ribs and high, broad, varices. Each varix with short, blunt nodes extending from primary spiral cords. Antepenultimate, penultimate and last whorls with three varices and a single, strong, prominent, intervarical node. Other spire whorls with narrow axial ribs. Last whorl broad. Subsutural area with adis, IP, abis, followed on convex part of whorl by P1, s1, P2, s2, P3, s3, P4, s4, P5, s5, P6, s6; ADP and MP on siphonal canal. P1-P6 almost similar in size and strength, P6 weakly narrower. Secondary cords obviously narrower than primary cords. Siphonal canal below MP missing or damaged. Aperture moderately small, ovate. Columellar lip narrow, smooth, adherent. Anal notch shallow, broad. Outer apertural lip with very shallow ID and strong D1-D5 within. Labral varix rounded, strong, broad, with small nodes. Siphonal canal short, narrow, ventrally sealed, partly broken.

Discussion. Vermeij & Vokes (1997, p. 72) restrict the genus *Ocenebra* to "a relatively small number of Miocene to Recent species from western Europe, the Mediterranean region and Tropical West Africa. These are characterized by the tendency to form three varices on the last whorl, by the presence of six to eight primary spiral cords on the last whorl, a crenulated outer lip without a labral tooth, an adherent or very lightly erect inner lip, and six weak to strong denticles on the inner side of the outer lip. In species with varices, the latter are separated from each other by a single intervarical node".

The Tropical West African species are now classified in other genera. However, Houart & Sirenko (2003) also assigned three Recent and fossil species from the northwestern Pacific to *Ocenebra*.

Two more or less related species were assigned to *Miocenebra*: *M. silverdalensis* (Vokes, 1963) and to *Fenolignum*: *F. umbilicatum* Vermeij & Vokes, 1997, by Vermeij & Vokes (1997), both species from the Belgrade Formation, North Carolina.

This is the first occurrence of the genus *Ocenebra* in the tropical western Atlantic and therefore this new species cannot be compared to any Caribbean fossil or Recent taxon. *Ocenebra etteri* nov. sp. is far more reminiscent of some of the Early Miocene Aquitanian and Burdigalian species from the French Aquitaine Basin (see Lozouet *et al.*, 2001, pl 22, 23).

Genus *Vitularia* Swainson, 1840

Type species. – *Murex miliaris* Gmelin, 1791, by monotypy. Recent, western Indo-Pacific.

Note. – The placement of this genus in the Ocenebrinae Cossmann, 1903 is provisional, as molecular data presented by Barco *et al.* (2010) showed the subfamily to be polyphyletic.

Vitularia* sp. cf. *V. salebroza

(King & Broderip, 1832)

Figures 24-27

cf. 1832 *Murex salebroza* King & Broderip, p. 347.

Material. 1 incomplete specimen, NHMW 2012/0197/0008 (ex BL coll.), height 29.1 mm (Figs 24-25); 1 incomplete specimen, NMB H20169, NMB locality 12842, height 72.2 mm (Figs 26-27).

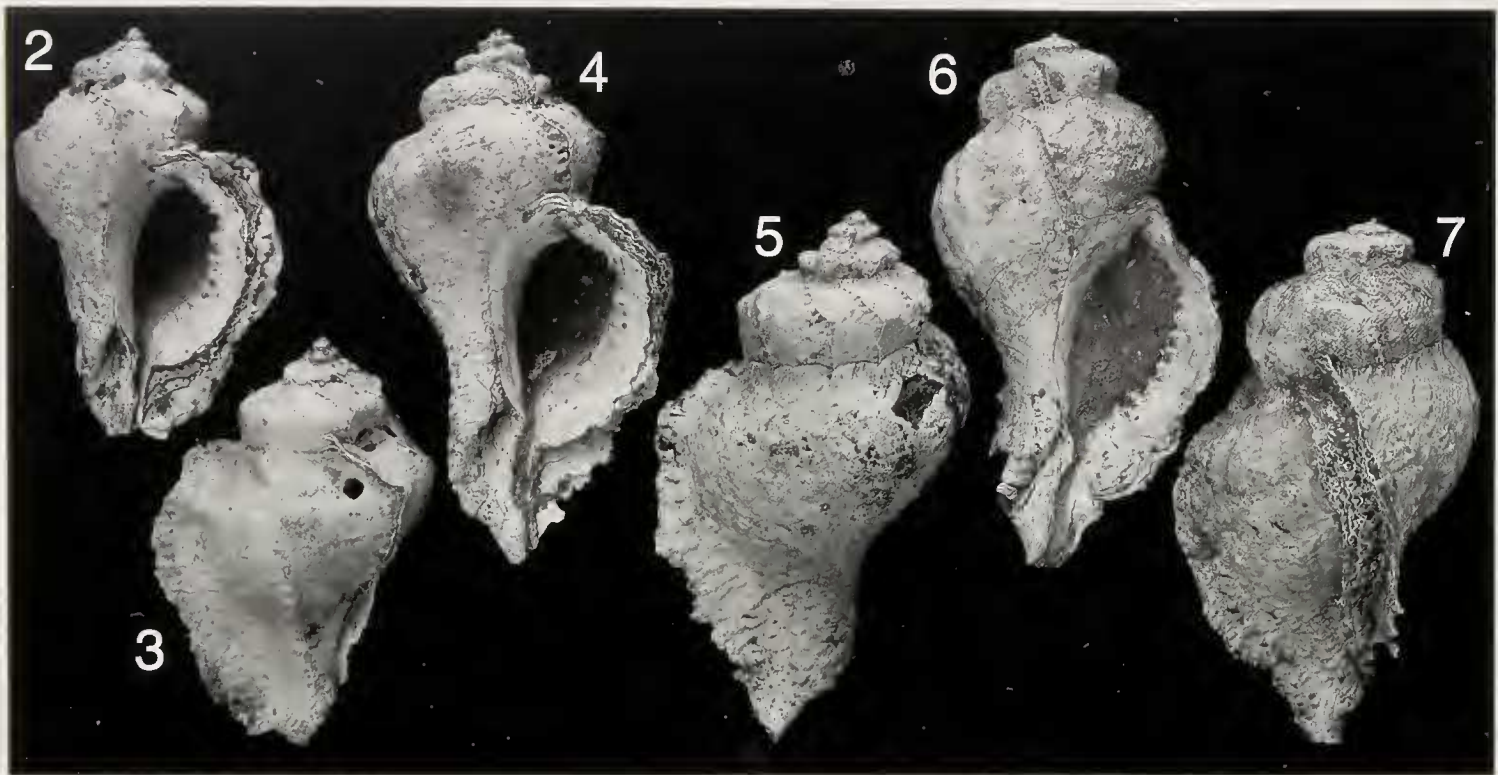
Locality. 1 km southwest of Casa Cantaure, about 10 km west of Pueblo Nuevo, Falcón, Venezuela (= locality GS1PGNA of Gibson-Smith & Gibson-Smith, 1979), Cantaure Formation (early Miocene: Burdigalian).

Discussion. A *Vitularia* species occurs in the Cantaure formation, which is difficult to characterise as only two incomplete specimens are available to us, and they are somewhat different from each other. The first of these is smaller and probably represents a subadult stage (Figs 24-25). The shell is slender and the spire high. The carina on the spire whorls is sharp and runs mid-whorl. The subsutural ramp is broad and weakly concave, below the carina the whorl is straight-sided and tapers inwards to the suture. The axial sculpture consists of eight prosocline ribs developed into prominent rounded tubercles at the shoulder. The ribs cross the subsutural ramp as narrow lamellae. The surface is pustulose, a feature of the genus. Unfortunately the adapical portion of the last whorl and aperture are missing. This is the specimen discussed by Landau *et al.* (2013). The second specimen (Figs 26-27) is larger, but strongly abraded and incomplete. The spire is also high, and the shoulder bears rounded tubercles. However, it differs in the position of the carina on the spire whorls, which is closer to the adapical suture, giving the spire a conical rather than scalate shape. The two *Vitularia* specimens from Cantaure probably represent a single species, as these differences in the position of the suture and spire shape can also be seen in the European Miocene *Vitularia linguabovis* (Basterot, 1825) (Landau *et al.*, 2013).

The genus is not speciose. In the Caribbean faunas only two species are known. *Vitularia dominicana* Vokes, 1989 from the early Pliocene Gurabo Formation of the Dominican Republic is low spired, and according the illustrated holotype, has large round

tubercles at the shoulder, which is placed high on the last whorl. At the time of description only three specimens were available to Emily Vokes, with a maximum height of 28.2 mm. Subsequent collections made by the senior author have brought further specimens to light, which attain a greater maximum height of 53.9 mm. As the shell increases in size the penultimate and last whorls become rounded and lose

the tubercles at the shoulder. In the largest specimens from the Dominican Republic the shoulder of the last whorl is rounded and quite smooth. In view of these important and, so far undocumented ontogenic changes, we take the opportunity to illustrate further specimens from the Dominican Republic (Figures 2-7).



Figures 2-7. *Vitularia dominicana* Vokes, 1989, Tulane locality 1215 (see Vokes, 1989), Gurabo River, Gurabo Formation, Lower Pliocene, Dominican Republic. Figs 2-3 NHMW 2013/0476/0005, height 40.8 mm; figs 4-5 NHMW 2013/0476/0006, height 53.7 mm; figs 6-7 NHMW 2013/0476/0007, height 49.5 mm.

Vokes (1989) compared the Dominican shell to the Recent Indo-Pacific species *Vitularia miliaris* (Gmelin, 1791), but large specimens of this species always have large tubercles at the shoulder, which remains angular and placed high on the last whorl.

The second species is *Vitularia salebrosa* (King & Broderip, 1832) (= *V. ecuadoriana* Marks, 1951 = *V. linguabison* Vokes, 1967). This species occurs in the Caribbean Neogene in the late Pliocene Agueguexquite Formation of Mexico and Pinecrest Formation of Florida, in the Panamic faunas from the early Pliocene Esmeraldas Group of Ecuador, through the Pleistocene of Baja California, Ecuador and the Galapagos, and is found today from Baja California to Peru. It is one of the paciphile species discussed by Landau *et al.* (2009). *Vitularia salebrosa* is tall-spined, like the *Cantaure* specimens, but seems to have smaller and more numerous tubercles at the shoulder. *Vitularia linguabovis* (Basterot, 1825), which occurs in the early-late European Miocene, is broader, usually with a less elevated spire, and more numerous tubercles at the shoulder. We wait in the hope of finding better specimens from *Cantaure*, which is the earliest occurrence of the genus in the tropical American Neogene assemblages.

Subfamily **TYPHINAE** Cossmann, 1903

Genus *Typhina* Jousseume, 1880

Type species. – *Typhis belcheri* Broderip, 1833 (= *Murex cleryi* Petit, 1840) by original designation, Recent, West Africa and Brazil.

= *Talityphis* Jousseume, 1882

Talityphis Jousseume, 1882 and *Typhina* Jousseume, 1880 were considered congeneric by Houart (2002).

Typhina canaliculata nov. sp.

Figures 8, 28-34

Dimensions and type material. Holotype; NHMW 2013/0476/0001 (ex BL coll.) (Figs 28-31), height 28.6 mm; paratype 1; NHMW 2013/0476/0002 (ex BL coll.) (Figs 8, 32-34), height 23.8 mm; paratype 2; NHMW 2013/0476/0003 (ex BL coll.), height 28.9 mm; paratype 3 NMB H20171 (NMB locality 17520), height 19.9 mm; paratype 4 NMB H20170 (NMB locality 17516), height 27.9 mm; paratype 5 NMB H19068 (NMB locality 17516), height 27.7 mm.

Other material. Maximum height 30.3 mm; 10 specimens NHMW 2013/0476/0004 (ex BL coll.), NMB locality 17516 NMB coll. (6), same locality.

Etymology. Name reflecting the deeply canaliculated suture seen in this species.

Type locality. 1 km southwest of Casa Cantaure, about 10 km west of Pueblo Nuevo, Falcón, Venezuela (= locality GS1PGNA of Gibson-Smith & Gibson-Smith, 1979).

Type stratum. Cantaure Formation (late early Miocene: Burdigalian).

Diagnosis. A medium-sized *Typhina* species, with a relatively high spire, strongly concave subsutural area resulting in a deeply canaliculated suture, four varices per whorl, short tubes, five weakly developed spiral cords forming weakly recurved spines on the varices, and a moderately expanded labral varix.

Description. Shell medium-sized, stout; spire

relatively high. Protoconch not preserved. Six or seven sharply-angular, straight-sided teleoconch whorls, with narrow, deeply concave subsutural area. Suture impressed, deeply canaliculated. Four varices per whorl. Tubes (P1) of moderate length, pointing laterally and abaperturally, placed closer to preceding than succeeding varices. A laminar partition above the aperture crossing the shoulder joins the varix to the varix of the preceding whorl. Below tube shell surface very weakly swollen and two lines pass anteriorly, one being the margin of the old mouth, the other, in advance of the tube, being similar in character and indicating another arrest in growth. P2-P6 weakly developed, forming small, posteriorly-reflected spines over the varices. Surface bearing faint growth lines. Aperture small, ovate, bordered by raised rim; labral varix constant in width, moderately expanded, consisting of inner band bearing spiral cords and outer flange with a scalloped edge formed by spines at termination of P2-P6. Siphonal canal closed, broad, relatively short, pointing to the right and abaperturally.

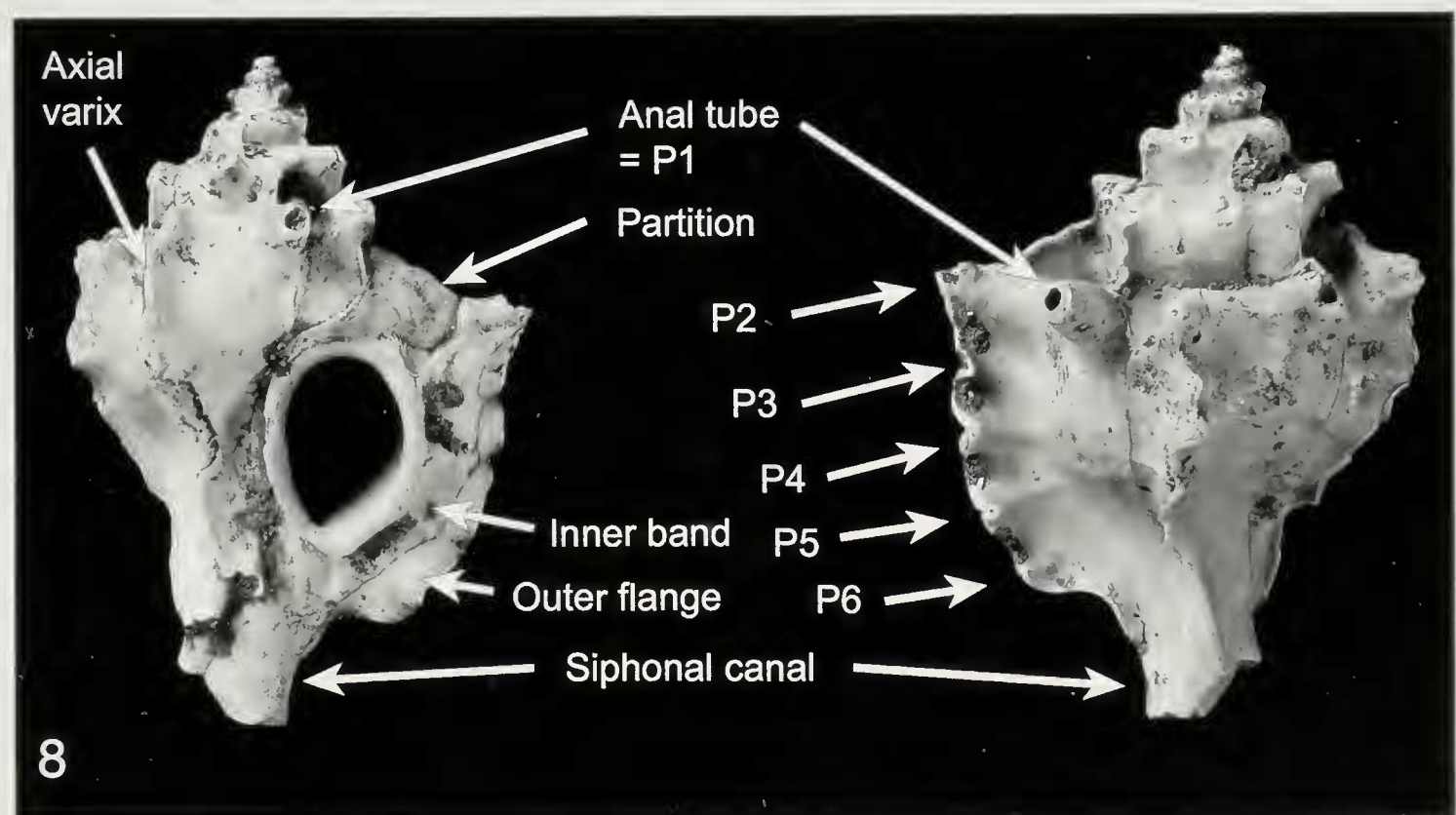


Figure 8. *Typhina canaliculata* nov. sp., paratype 1 NHMW 2013/0476/0002 (ex BL coll.), height 23.8 mm, 1 km southwest of Casa Cantaure, about 10 km west of Pueblo Nuevo, Falcón, Venezuela, Cantaure Formation, Burdigalian, late early Miocene.

Discussion. The four varices and tubes per whorl, the tubes being placed closer to the preceding than succeeding varix, the apertural varix greatly expanded and the partition above the aperture place this new species in the genus *Typhina* Jousseaume, 1880.

Typhina canaliculata nov. sp. resembles the Recent and type species *T. belcheri* (= *T. cleryi*) but it differs in having a comparatively larger shell with a higher spire, a straighter, less upward bent and shorter P2 spine instead of long and strongly adapically recurved

in *T. belcheri*, a more sculptured, more strongly folded apertural varix and a comparatively broader siphonal canal.

Typhina canaliculata nov. sp. is also closely similar to *Typhina obesa* (Gabb, 1873), which is widespread in the Caribbean early Miocene (Vokes, 1989), but differs in being less broad and in having a taller spire, whereas *T. obesa* has a very short, depressed spire. The subsutural area in *T. obesa* is broad and weakly concave, whereas in *T. canaliculata* it is narrower and

strongly concave, resulting in a deeply canaliculated suture, bordered by a high-ridged shoulder. In *Typhina canaliculata* the spiral cords are more strongly developed than in *T. obesa*, forming short recurved spines at the varices on the last whorl. In *T. obesa* the spiral sculpture is very weakly developed, hardly marked over the sharp, straight varices. Lastly, the aperture is relatively smaller and the labral varix narrower than in *T. obesa*. *Typhina expansa* (Sowerby, 1874) from the early Pliocene to Recent Caribbean, is very closely similar to *T. obesa* (differences between the two were discussed by Vokes, 1989, p. 332), but this species can also be distinguished from *T. canaliculata* in having a broader shell shape and in having a wider apertural varix, but above all by the less concave subsutural area. *Typhina alata* (Sowerby, 1850) from the early Pliocene Gurabo Formation of the Dominican Republic and Pliocene formations of Ecuador differs in having a more fusiform shell shape, a less depressed subsutural area, a wider labral varix and in forming an intervarical node below the tubes, a character not seen in *T. obesa*, *T. expansa* or *T. canaliculata*.

The earliest member of the genus in the Caribbean was thought to be *Typhina precursor* (Keen & Campbell, 1964) from Las Perdices Shale of Colombia, which, according to Gertman (1969), was dated as Aquitanian early Miocene. This species also occurs in the Manzanilla Formation of Trinidad, dated by Gertman as early Miocene. The age of the Las Perdices Group is now considered middle-late Miocene (Landau *et al.*, 2012, chart 2), and the Manzanilla Formation is considered to be late Miocene (Landau *et al.*, 2012, chart 15). *Typhina precursor* is a very large solid species, 47-49 mm in height, which also seems to have a narrow shoulder, but differs importantly from *T. canaliculata* and other *Typhina* species in having no spiral sculpture developed.

Other Caribbean congeners are: *Typhina pterina* (Gardner, 1947) from the middle Miocene Shoal River Formation of Florida and *T. eucteana* (Woodring, 1970) from the late Miocene Gatun formation of Panama, which are both much smaller, with a more fusiform shell shape. The subsutural area in both of

these is concave, but not as deep as in *T. canaliculata*. *Typhina eucteana* is further distinguished by its long, narrow siphonal canal. *Typhina siphon* (Woodring, 1928) from the Pliocene Bowden Formation of Jamaica is a more slender, fusiform species, with recurved spines at the shoulder, and a longer siphonal canal. *Typhina acuticosta* (Conrad, 1830) from the middle Miocene St. Mary Formation of Maryland and late Miocene Choctawhatchee Formation of Florida is quite different, with a slender shell shape and acutely angled, straight-sided whorls. *Typhina carmenae* (Gertman, 1969) from the late Pliocene Agueguexquite Formation of Mexico has a broader shell shape, more prominent spiral sculpture and a far more expanded apertural varix than *T. canaliculata*. The Recent Panamic *Typhina latipennis* (Dall, 1919) has weaker spiral sculpture than the fossil Cantaure species, and a greatly expanded flange on the apertural varix.

Genus *Laevityphis* Cossmann, 1903

Type species. – *Typhis coronarius* Deshayes, 1865 [*Laevityphis muticus* (Sowerby, 1835)], by original designation. Eocene, France.

Laevityphis jungi nov. sp.

Figures 35-38

Typhis (Laevityphis) sawkinsi. Jung, 1965, p. 525, pl. 70, figs 7, 8 [not *Laevityphis sawkinsi* (Mansfield 1925)].

Dimensions and type material. Holotype: NHMW 2013/0476/0012 (ex BL coll.) (Figs 35-36), height 28.3 mm; paratype 1: NHMW 2013/0476/0013 (ex BL coll.) (Figs 37-38), height 27.0 mm; paratype 2: NHMW 2013/0476/0014 (ex BL coll.), height 27.1 mm; paratype 3: NHMW 2013/0476/0015 (ex BL coll.), height 23.8 mm; paratype 4 NMB H18542, height 23.0 mm; paratype 5 NMB H18543, height 20.7 mm; paratype 6 NMB H13719, height 23.0 mm [specimen figured by Jung, 1965, pl. 70, figs 7, 8 as *Typhis (Laevityphis) sawkinsi* Mansfield].

Figures 9-23

9-11. *Siratus harzhauseri* nov. sp., holotype NHMW 2013/0476/0010 (ex BL coll.), height 48.6 mm.

12-13. *Phyllonotus* sp. cf. *P. infrequens* (Vokes, 1963), NHMW 2013/0476/0011 (ex BL coll.), height 35.3 mm.

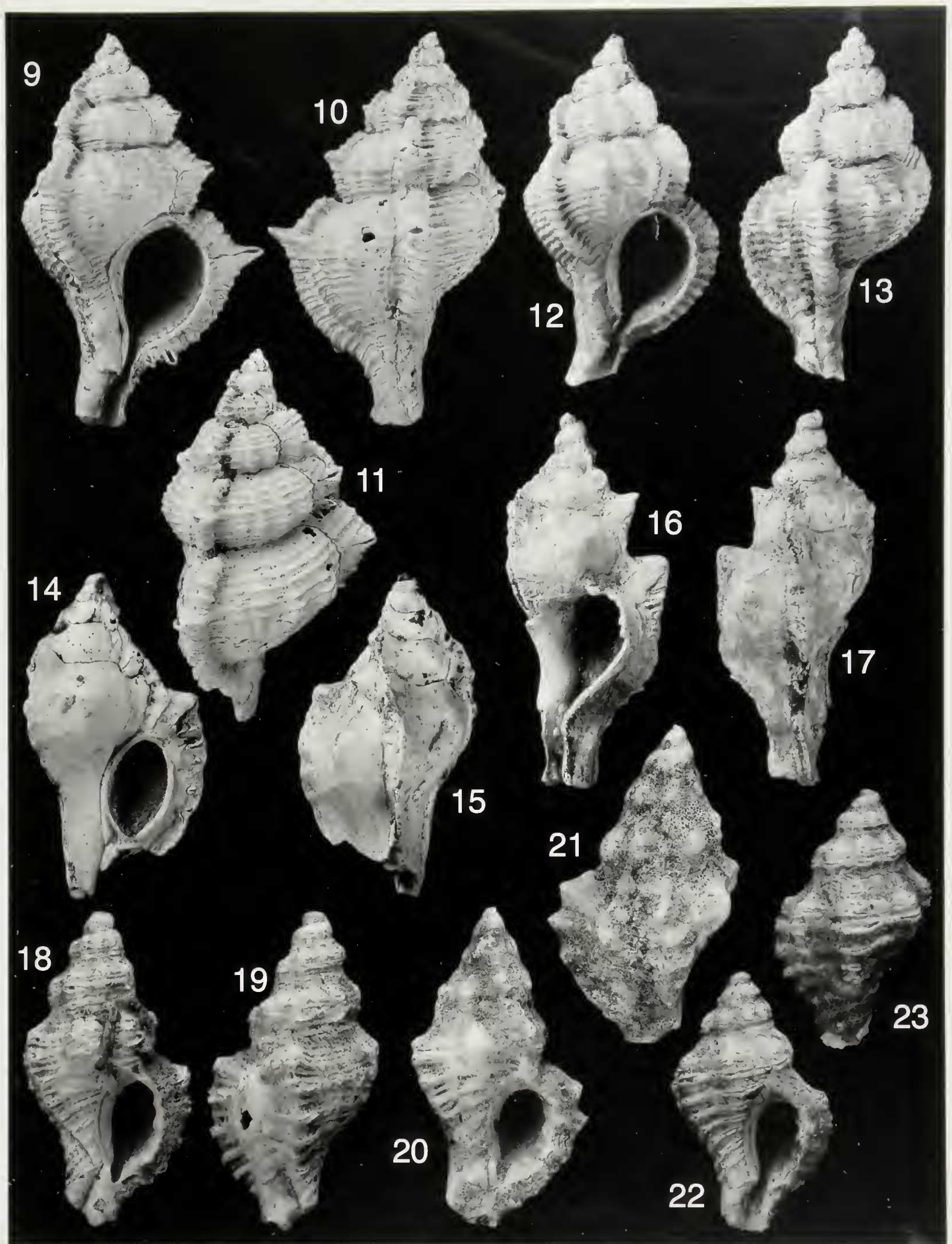
14-17. *Purpurellus* sp. cf. *P. repetiti* (Vokes, 1970)

14-15. NHMW 2013/0476/0008 (ex BL coll.), height 27.2 mm; **16-17.** NHMW 2013/0476/0009 (ex BL coll.), height 32.4 mm.

18-23. *Ocenebra etteri* nov. sp.

18-19. Paratype 1, NHMW 2013/0476/0017, height 17.5 mm; **20-21.** Holotype, NHMW 2013/0476/0018, height 22.3 mm; **22-23.** Juvenile, NHMW 2013/0476/0020, height 14.0 mm.

All: 1 km southwest of Casa Cantaure, about 10 km west of Pueblo Nuevo, Falcón, Venezuela, Cantaure Formation, Burdigalian, late early Miocene.



Other material. Maximum height 31.7 mm; 20 specimens NHMW 2013/0476/0016 (ex BL coll.), NMB locality 17516 NMB coll. (66), NMB locality 17520 NMB (100+), same locality.

Etymology. Named in honour of Peter Jung, in recognition of his work on the Cantaure assemblage.

Type locality. 1 km southwest of Casa Cantaure, about 10 km west of Pueblo Nuevo, Falcón, Venezuela (= locality GS1PGNA of Gibson-Smith & Gibson-Smith, 1979).

Type stratum. Cantaure Formation (late early Miocene: Burdigalian).

Diagnosis. A medium-sized *Laevityphis* species, with a high spire, a narrow, concave subsutural area, four varices per whorl placed in the middle of the intervarical area, bearing spines pointing adapically and inwards, short tubes in the intervarical spaces, an almost smooth surface, a small aperture, a narrowly expanded labral varix, and a long, narrow siphonal canal.

Description. Shell medium-sized, elongate; spire high. Protoconch paucispiral, consisting of two elevated, bulbous whorls. Six or seven sharply-angular teleoconch whorls, with narrow, concave, sub-horizontal subsutural area, weakly convex below shoulder to suture. Suture impressed, undulating. Four simple, convex varices per whorl, with a large, sharp spine at the shoulder of each varix pointing adapically and inwards; end usually broken away and appearing as small tube-like structures, but not connecting to interior of shell. Tubes (P1) of moderate length, separated from varices, pointing laterally and abaperturally, placed in the middle of the intervarical area. A ridge running abapically from the tube dividing the intervarical area into two almost equal halves. Last whorl relatively short, convex, strongly constricted at the base. P2-P6 not clearly developed,

very weak spiral sculpture just visible on penultimate and last whorls. Aperture small, ovate, bordered by raised rim; labral varix constant in width, moderately expanded. Siphonal canal closed, narrow, long, pointing to the right and abaperturally at distal end.

Discussion. The four varices and tubes per whorl, the tubes not being attached to the varix, the varix bearing a spine pointing apically and the narrowly expanded apertural varix place this new species in the genus *Laevityphis* Cossmann, 1903 (Gertman, 1969). In this genus the tube is usually placed closer to the succeeding than the preceding varix, although in *Laevityphis jungi* nov. sp. the tube is placed almost midway between the varices.

This species was first identified by Jung (1965) as *Typhis (Laevityphis) sawkinsi* (Mansfield, 1925) from the early-middle Miocene Brasso Formation of Trinidad, although the author noted that the Cantaure shells were not identical with those from Trinidad. When compared to the holotype figured by Gertman (1969, pl. 7, fig. 1), the Trinidadian species is much stockier, with a far shorter spire, the varices are far wider and more prominent than in *L. jungi*, the base is less strongly constricted and the siphonal canal is broader and shorter than in the Venezuelan species.

The fact that the Venezuelan and Trinidadian species were not conspecific was noted by Vokes (1989, p. 81), who considered the Cantaure shells to be a rather large variant of *Laevityphis linguiferus* (Dall, 1890) a species common in the early Miocene Chipola Formation of Florida. Indeed, Vokes (1989) considered the two identical, apart from their size. We have compared the Cantaure material with numerous specimens of *L. linguiferus* from the Chipola Formation and cannot agree with this conclusion. *Laevityphis jungi* is indeed a much larger shelled species, adults ranging from 22.7 mm – 31.7 mm in height, whereas the largest specimens of *L. linguiferus* do not attain 15 mm in height. Further differences can be seen in the spire, which is much taller in the Venezuelan species and the last whorl, which is more

Figures 24-38

24-27. *Vitularia* sp. cf. *V. salebrosa* (King & Broderip, 1832)

24-25. NHMW 2012/0197/0008 (ex BL coll.), height 29.1 mm; 26-27. NMB H12842, height 72.2 mm.

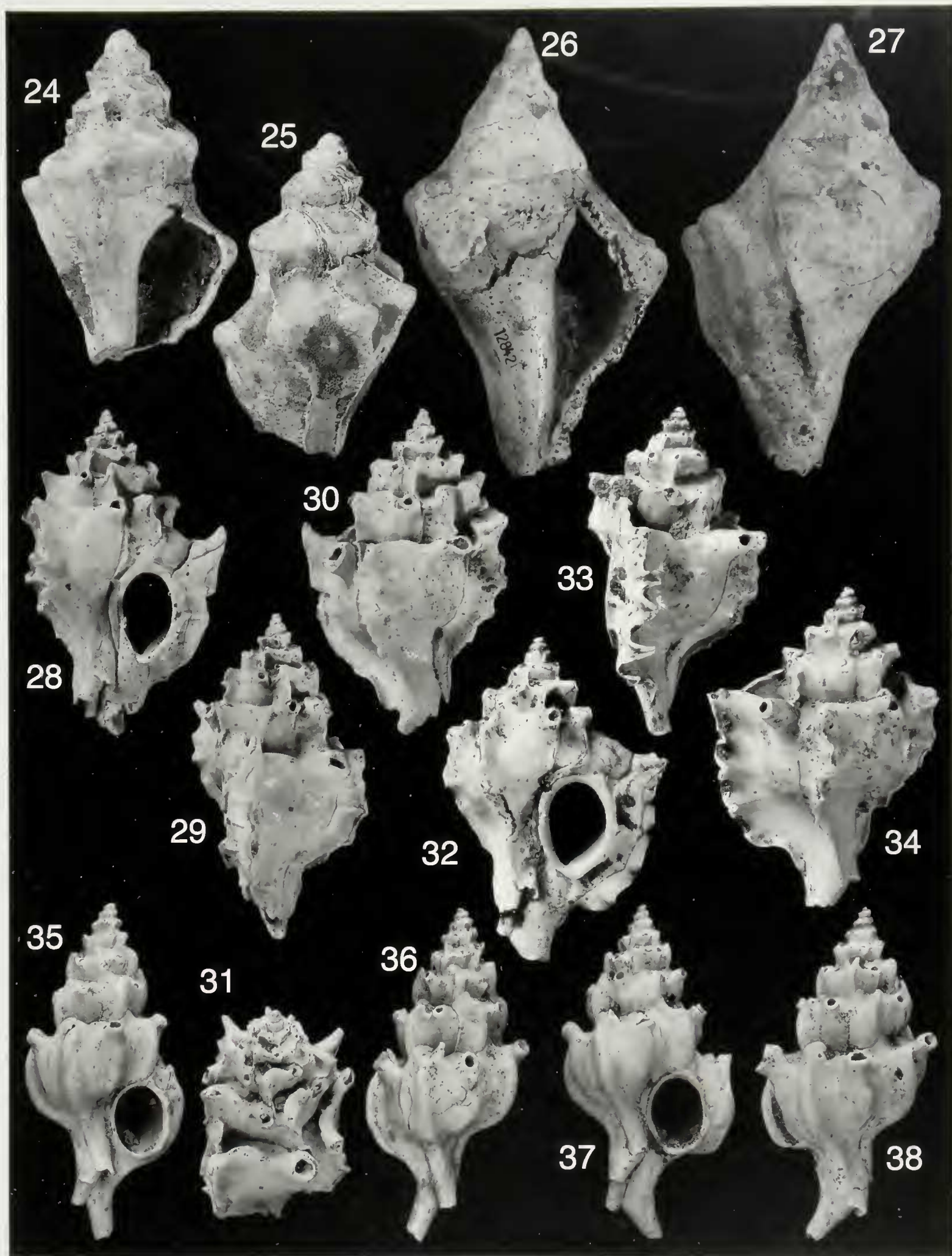
28-34. *Typhina canaliculata* nov. sp.

28-31. Holotype; NHMW 2013/0476/0001 (ex BL coll.), height 28.6 mm; 32-34. Paratype 2; NHMW 2013/0476/0003 (ex BL coll.), height 28.9 mm.

35-38. *Laevityphis jungi* nov. sp.

35-36. Holotype; NHMW 2013/0476/0012 (ex BL coll.), height 28.3 mm; 37-38. Paratype 1; NHMW 2013/0476/0013, (ex BL coll.), height 27.0 mm.

All: 1 km southwest of Casa Cantaure, about 10 km west of Pueblo Nuevo, Falcón, Venezuela, Cantaure Formation, Burdigalian, late early Miocene.



constricted at the base. The proximal end of the siphonal canal is proportionally broader in *L. linguiferus* than in *L. jungi*, but then narrows rapidly at the distal end to form a very small siphonal exit, whereas in *L. jungi* the narrowing is gradual and the siphonal exit proportionally wider. The sculpture, or lack of it, is similar in both species.

Several congeners occur in the tropical American fossil record. The oldest member of the group, *L. gracilis* (Conrad, 1833) from the late middle Eocene Gosport Formation of Alabama, USA also has a slender shell and tall spire, but is distinguished by its crenulated varices. The other Miocene and Pliocene congeners, such as *L. costaricensis* (Olsson, 1922), *L. bullisi* (German, 1969), *L. apheles* (Vokes, 1989) and *L. spinirectus* (Vokes, 1989) all differ in having smaller, less slender shells with lower spires.

ACKNOWLEDGEMENTS

We would like to thank Emily Vokes for her comments and for acting as referee. Also to Walter Etter and Olivier Schmidt of the Naturhistorisches Museum Basel, Switzerland, for access to the PPP collection.

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